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COST EFFECTIVE REGIONAL BALLISTIC MISSILE DEFENSE

by

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Biography

Colonel Christopher Ford is assigned to the Air War College, Air University, Maxwell AFB, AL. He was commissioned an Army Second Lieutenant in 1993. Colonel Ford holds a Bachelor of Science Degree in Logistics and Transportation from the University of Tennessee, Knoxville and a Master of Science Degree in Logistics Management from the Florida Institute of Technology.

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Abstract

Within the strategic context of increasing capable threats and declining defense budgets, regional ballistic missile defense (BMD) plays a key role in protecting and advancing our national interests.[1] However, this defensive capability is limited and has not kept pace with the increasingly rapid proliferation of regional ballistic missiles. This directly challenges the nation's ability to deter and defeat aggression through power projection of our military forces. We must identify the ways and means to counter this imbalance or risk future erosion of our military effectiveness, diminished allied confidence, and unnecessarily shameful loss of life. The 2015 National Military Strategy emphasizes actions designed to improve the U.S. military's agility, innovation, and integration through greater efficiencies and delivery of advanced military capabilities. Yet, neither the current ballistic missile defense strategy nor current processes align with the innovative slant of the Department's latest overarching strategy. In a fiscally constrained environment, both require innovative thought and coordinated effort to efficiently resource future success. Current U.S. strategy to develop and field regional ballistic missile defenses, while a credible deterrent, is deficient and requires meaningful revision. The current strategic plan is woefully dated and corporate processes are not adequately synchronized to provide efficient, timely solutions. Due to a myriad of reasons including fiscal realities and threat capabilities, the Department of Defense (DoD) must re-assess key tenets of its Ballistic Missile Defense strategy and strive to innovate its processes in order to cost effectively match ends, ways, and means to defend against future regional ballistic missile threats.

The protection of the United States from the threat of ballistic missile attack is a critical national security priority. The threat to our deployed military forces and to our allies and partners is growing rapidly. This threat has significant implications for our ability to project power abroad, to prevent and deter future conflicts, and to prevail should deterrence fail.[2]

Robert Gates
Secretary of Defense
February 1, 2010

It is the sense of Congress that—(1) the regional ballistic missile capabilities of countries such as Iran and North Korea pose a serious and growing threat to forward deployed forces of the United States, allies, and partner countries… given this growing threat, it is a high priority for the United States to develop, test, and deploy effective regional missile defense capabilities to provide the commanders of the geographic combatant commands with capabilities to meet the operational requirements of the commanders, and for allies and partners of the United States to improve their regional missile defense capabilities; ...[3]

National Defense Authorization Act
(Public Law 113-291)
Fiscal Year 2015
Section 1666

Introduction

With these words, Secretary Gates and Congress continue to reinforce the importance of ballistic missile defense to "significantly improve the security of the United States and its allies while also enhancing international stability."[4] Since Germany launched the world's first ballistic missile (BM), the infamous V-2, against Great Britain on 8 September 1944 and began active development of longer-range ballistic missiles capable of striking targets in the United States[5], American military leaders have clearly recognized the imminent threat posed by ballistic missiles to our national interests. Seventy years and $173 billion later[6], the United States has developed and deployed "a layered ballistic missile defense system (BMDS) to defend the United States, its deployed forces, allies, and friends from ballistic missile attacks of all ranges in all phases of flight."[7]

Within the strategic context of increasing capable threats and declining defense budgets, regional ballistic missile defense (BMD) plays a key role in protecting and advancing our

national interests.[8] However, this defensive capability is limited and has not kept pace with the increasingly rapid proliferation of regional ballistic missiles. This directly challenges the nation's ability to deter and defeat aggression through power projection[9] of our military forces. We must identify the ways and means to counter this imbalance or risk future erosion of our military effectiveness, diminished allied confidence, and unnecessarily shameful loss of life. The 2015 National Military Strategy emphasizes actions designed to improve the U.S. military's agility, innovation, and integration through greater efficiencies and delivery of advanced military capabilities.[10] Yet, neither the current ballistic missile defense strategy nor current processes align with the innovative slant of the Department's latest overarching strategy. In a fiscally constrained environment, both require innovative thought and coordinated effort to efficiently resource future success.

Thus, this paper emphasizes the importance of a cogent national BMD strategy and effective bureaucracy to maximize the return on national investments within the current strategic environment. First, it reviews the ever-increasing threat environment and the current U.S. response. Second, this paper articulates the inadequacy of the current BMD strategy forming the argument for a new missile defense plan to guide collective national efforts. Third, it examines existing weaknesses of the DoD bureaucracy to identify potential novel approaches to speed capability delivery in a more coordinated fashion. Finally, several recommendations are proposed to increase long-term cost effectiveness.

Thesis

This research paper uses a qualitative approach to argue that the current U.S. strategy to develop and field regional ballistic missile defenses is deficient and requires meaningful revision. Due to a myriad of reasons including fiscal realities and threat capabilities, the

Department of Defense (DoD) must re-assess key tenets of its Ballistic Missile Defense strategy and strive to innovate its processes in order to cost effectively match ends, ways, and means to defend against future regional ballistic missile threats. The current strategic plan is woefully dated and corporate processes are not adequately synchronized to provide efficient, timely solutions.

The Ballistic Missile Strategic Environment

The Ballistic Missile Threat Revolution in Military Affairs (RMA)[11]

The 1991 Gulf War was the last conflict where regional ballistic missile defenses were roughly equal to threat missiles. Moreover, ballistic missiles were generally inaccurate and followed a predictable attack doctrine that could be easily countered. As part of an anti-access, area-denial (A2/AD) scheme, U.S. adversaries have developed offensive ballistic missile inventories and technology capable of overwhelming our defensive means and impeding our ability to project power globally.[12] Today, over 20 countries possess a ballistic missile arsenal[13] and these arsenals have grown by over 1,200 ballistic missiles in the past five years with over 5,900 outside the control of the United States, the North Atlantic Treaty Organization (NATO), China, and Russia.[14] Most strikingly, 99% of these weapons are regional threats.[15]

Technology transfer has also accelerated ballistic missile proliferation while capability advancements have simultaneously accelerated their effectiveness. Technology transfer has been the principal source of proliferation thanks primarily to Russia, China, and North Korea who have collectively spread BM technology to over 13 countries in recent years.[16] Russia alone has exported ballistic missiles and associated technology to over 12 countries. Ballistic missiles today are also much more capable due to solid fuel upgrades, improved launcher mobility, greater ranges, improved warhead lethality, effective countermeasures, advanced penetration

aids, and enhanced guidance systems. To lend credibility to their arsenal, adversaries work diligently to increase their training proficiency and system reliability through live-fire exercises. China, Iran, and North Korea execute mass raid salvo launches of varying sizes each year.[17] Additionally, many countries are protecting key infrastructure including their ballistic missile force by deploying advanced air defense systems[18], such as the Russian S-300 and S-500, and concealing them in hardened, camouflaged sites, such as extensive Chinese tunnels.

Even more challenging, China and Russia are developing WU-14 and Yu-70 hypersonic glide vehicles (HGV) to deliver heavier payloads, on a non-ballistic trajectory, more precisely at a speed over Mach 5.[19] This game-changing weapon would essentially render current and planned BMDS capabilities ineffective.[20]

The dual benefits of asymmetric effectiveness and cost drive adversary rationale for ballistic missiles. Due to their speed and modular warhead capacity, ballistic missiles can defeat strong air defense systems and deliver conventional or nuclear, biological, or chemical (NBC) warheads. An actor can thus use them to either deter aggression or coerce action within their region. From a cost perspective, it is simply not cost-effective for most potential opponents to build and maintain an air force capable of matching U.S. aircraft inventories. For the $114 million procurement cost of a single F-35 aircraft[21], a country could acquire 100 CSS-6 or CSS-7 short-range ballistic missiles (SRBM) capable of striking targets accurately up to 550 miles away.[22] Missiles also offer the benefits of less training and reduced sustainment costs for maintenance and system support. Thus, ballistic missiles provide a cost-effective means to ensure a state's freedom of action and prevent other regional players, including the U.S., from attaining their objectives.[23]

Thus, threat systems are now more numerous, responsive, survivable, accurate, and effective. Taken together, global missile forces represent an increasingly credible threat capable of neutralizing our ability to project power globally.

Current U.S. Ballistic Missile Defense Policy

The key priorities of U.S. BMD policy are to defend against limited ICBM attacks against the homeland, to defend deployed U.S. forces and allies from regional missile threats, to ensure U.S. BMD capabilities remain flexible against evolving threats, and to expand international missile defense efforts.[24] These priorities have remained generally unchanged over the past 25 years and have driven development of multiple BMD systems and extensive efforts to expand partner BMD capabilities.

The U.S. has established BMD as an essential component of protection for forward-deployed U.S. forces and credible deterrence against ballistic missile attacks. According to the 2010 Ballistic Missile Defense Review (BMDR), ballistic missile defense coupled with other U.S. elements of national power strengthens regional defense during peace, escalation, and direct conflict. BMD provides reassurance to our allies of U.S. security commitments, deters coercive threats with ballistic missiles, preserves U.S. and allied freedom of maneuver, and ultimately provides for mutual defense by mitigating the effects of ballistic missile attacks.[25] As a matter of policy, defense against regional threats is not defined as limited. Yet, the U.S. possesses a quantitatively limited defensive capability today due to technical complexity and costs.

U.S. Regional Ballistic Missile Defense System (BMDS)

When Iraq launched SCUD missiles against the coalition during Operation Desert Storm, it highlighted the risk to deployed forces. The qualified success of the Patriot system generated increased national priority on regional ballistic missile defense. While each U.S. administration

has adopted a slightly different approach, each has consistently underscored the importance of countering this threat to defend our allies and forward deployed troops.[26]

To this end, the U.S. has developed and fielded a multitude of means capable of detecting and kinetically engaging regional missiles with ranges up to 5,500 kilometers. These joint and interoperable capabilities consist of shooter, sensor, and command & control systems. The Army and Navy shooters include: 15 Patriot Advanced Capability (PAC-3) battalions with 60 firing batteries[27], two Terminal High Altitude Area Defense (THAAD) batteries[28], 33 Aegis BMD-capable ships[29], and one Aegis Ashore battery[30]. All of these systems provide varying degrees of flexible re-positioning and together can provide a two-tier engagement capability against longer-range threats. In addition to each shooter's organic sensor, the Missile Defense Agency (MDA) has also deployed several Army Navy / Transportable Radar Surveillance (AN/TPY-2) radars and has established an experimental space sensor capability with its Space Tracking and Surveillance System- Demonstrators (STSS-D). Finally, MDA has deployed the Command, Control, Battle Management, & Communications (C2BMC) system to every Combatant Command (CCMD) to integrate and synchronize all these capabilities, provide sensor data for homeland defense, and provide situational awareness to the national leadership.

This active defense system is significant and proven in operational testing. Yet, it possesses limitations that could potentially exacerbate the imbalance between supply and demand. Today, the U.S. only has approximately 389 upper tier[31] and 1,000 lower tier BMD interceptors. This is driven by high interceptor unit costs with THAAD and Aegis at over $10 million each[32] and the latest Patriot round at approximately $8.6 million.[33] Worse still, multiple interceptors are used to prosecute a single engagement resulting in a cost per kill of $17 million or more. Not only are interceptors limited and expensive, but only THAAD and Aegis Ashore

provide a dedicated BMD shooter capability because Aegis and Patriot weapons systems have multiple simultaneous defensive missions against aircraft, surface ships, and sub-surface threats. These realities could not only limit their availability for BMD but also exhaust finite interceptor inventories defending against air threats. Hence, a disparity between threat and capability, driven by technical capacity and fiscal constraints, elevates the significance of a contemporary strategy.

An Inadequate Strategy

The global ballistic missile threat continues to proliferate in quantity and capability while the existing U.S. BMD strategy has remained fixed. Current United States national policy is defined within the 2010 Ballistic Missile Defense Review (BMDR). This policy document clearly lays out the strategy and framework to resource investments for defense against ballistic missile threats of all ranges using all available resources and has successfully guided U.S. efforts. With a defensive capability focus, it prioritizes realistic testing, fiscal sustainability, system flexibility, and international cooperation. However, the United States requires an updated global missile defense strategy because the current approach is invalid and incomplete. BMD policy has remained static for nearly six years in a dynamic national security environment. Furthermore, unrealized BMDS capability, emerging technology, and allied capability have fundamental consequences for the U.S. active defense ballistic missile defense (BMD) strategy. Lastly, current national policy also largely ignores offensive and passive options to bolster BMD. Collectively, these points illustrate the shortcomings of a 2010 strategy to deliver a cost-efficient solution in the future.

National Security Change

First, the U.S. national security setting has experienced noteworthy change over the last six years including fluid Middle East turmoil, increased pressure on defense budgets, and

multiple cyclical updates of U.S. national and military strategy. While combat operations in Iraq and Afghanistan have ended, an advancing ISIS threatens to further de-stabilize Southwest Asia and has already gained control of a portion of the large Syrian ballistic missile inventory.[34] Meanwhile, the U.S. defense budget has declined by $131 billion over the past 6 years[35] and the MDA annual budget has remained relatively fixed at $7.9B[36]. Declining defense expenditures will likely continue and surely reduce BMD resources as well. Since publishing the BMDR and its first National Security Strategy (NSS) simultaneously in 2010, the current U.S. administration has also updated its National Military Strategy twice in 2011 and 2015, published updated joint integrated air and missile defense (IAMD) doctrine in 2013, completed a Quadrennial Defense Review (QDR) in 2014, and issued a new NSS in 2015. In addition to an advancing threat, each strategic document recognized the dramatic change of the proceeding six years and need for innovation. Yet, the nation's official BMD strategy has remained fundamentally unchanged.

Unrealized BMDS Capability

Second, the current strategy's key BMDS capabilities have not evolved as planned to achieve the desired breadth and prioritized flexibility against evolving threats. The BMDS has grown in capacity[37], but unfortunately, the sheer volume of unrealized capabilities outlined in the BMDR dwarfs these nominal advances. In 2015, the MDA intended to field an unmanned airborne infrared (IR) sensor capability. Per their website, this capability and an Early Intercept (EI) capability, to intercept missiles early in flight, are still listed as "potential technologies" indicating their nascent development status.

The 2010 BMDR also only lists two long-term capabilities: increasingly capable Aegis SM-3 missiles and the Precision Tracking and Space System (PTSS). However, the Department of Defense (DoD) is only procuring 52 of the newest SM-3 Block IIA interceptors[38] and

cancelled the objective SM-3 Block IIB missile to reduce Russian objections to the European Phased Adaptive Approach (EPAA) and fund homeland defense priorities.[39] Furthermore, the PTSS system was also cancelled in 2013 due to the budgetary pressures of sequestration.[40] Consequently, instead of an advanced space tracking constellation by 2018, the BMDS is limited to a single pair of experimental Space Tracking Surveillance System Demonstrators (STSS-D) that are already two years past their planned useful life and has an undefined, unresourced future space-based surveillance capability.

Due to these significant variations from the plan, the actual BMD means of 2015 and beyond look very different than those envisioned in 2010. While the MDA works diligently to field a robust BMDS to counter this aptly titled BM revolution in military affairs[41], the U.S. must pursue enduring investments as part of an updated strategy to augment existing BMDS active defense capabilities and replace unrealized capabilities.

The Potential of Emerging Technology

Third, emerging technology offers long-term opportunities to counter threat advances and deter ballistic missile use against friendly forces. In 2014, the Secretary of Defense recognized the pivotal role new technology must play as part of a Defense Innovation Initiative (DII) to counter advanced threats, like the hypersonic weapons, within a fiscally restrained environment.[42] While developmental systems like the Army's Integrated Battle Command System (IBCS) promise to increased flexibility and BMD effectiveness through a networked architecture,[43] revolutionary advances in the electromagnetic rail gun (EMRG) and directed energy (DE) weapons have potential to marginalize the utility of ballistic missile attacks in an economical manner.

After decades of development, the Navy has developed and is now running initial sea trials of an electromagnetic rail gun capable of launching guided projectiles out to 100 miles, at speeds of up to Mach 7, and with a cost-per-kill at a fraction of existing defensive missile systems.[44] By 2019, the Navy plans to demonstrate an initial operational capability which the Army has expressed interest in for missile defense. Additionally, DE technology has matured significantly in the past few years[45], the services are operationalizing high energy, solid-state lasers in nearly all domains, and DoD is investing over $200 million in DE research in FY16 alone[46].

Advanced technology development (ATD) efforts like the Army High Energy Laser Mobile Demonstrator (HEL-MD) and the MDA's Airborne Laser (ABL) have proven the concept of tracking and defeating a ballistic threat. Leveraging their proven capabilities, multiple domain solutions are possible. Recognizing that significant technical hurdles remain to mature these technologies, a coordinated and sincere effort appears practical to revolutionize missile defense.

Meanwhile, it is recognized that the best defense is sometimes a good offense. Thus, the United States is also pursuing hypersonic weapons for a conventional prompt global strike (CPGS) capability defined as "high-precision conventional weapons capable of striking a target anywhere in the world within one hour's time."[47] This CPGS capability would provide long-range offensive options in an A2/AD environment to destroy regional ballistic missile threats on the ground before launch. By avoiding a ballistic missile delivery means, the U.S. avoids any restrictions associated with the Intermediate-Range Nuclear Forces and Strategic Arms Reduction Treaties.[48] Moreover, this technology is relatively mature with successful flight

testing of the Army's Advanced Hypersonic Weapon (AHW) in 2011[49] and continued Congressional support for increased funding.[50]

Offering a cost per kill as low as a few dollars[51] and the potential for multiple military applications, these innovative technologies offer clear potential to field high-end, low cost-per-kill capabilities within the next decade promoting cost effective national defense by putting the U.S. on the right side of the cost curve. Consequently, emerging technologies must be aggressively pursued and part of any long-term active BMD strategy.

Allied BMD Capability Growth

Fourth, our allies recognize the limited capacity of the U.S. BMDS and have grown their BMD capability in concert with the U.S. strategy's regional phased adaptive approach (PAA) to deploy tailored regional ballistic missile defenses for regional deterrence in Europe, Southwest Asia, and East Asia.[52] Thus, U.S. policy has sought expanded international missile defense capabilities[53]. In Europe, NATO is actively working to develop its Active Layered Theater Ballistic Missile Defense (ALTBMD) declaring an initial operational capability (IOC) in January 2011.[54] Several European nations now possess over 45 Patriot Advanced Capability (PAC)-2 or PAC-3 batteries for short-range BMD, the French and Italians are co-developing a short-range BMD capability, the British are considering upgrading their Type 45 destroyers with a BMD tracking capability, and several countries are developing other passive defense capabilities.[55] Germany also recently decided to continue development and fielding of the MEADS AMD system by 2026, which will likely result in a similar decision by Italy in the near future.[56] In Southwest Asia, Gulf Cooperative Council (GCC) nations have acquired dozens of Patriot batteries and two THAAD batteries, while recently agreeing to begin developing a single GCC BMD defense network.[57] Meanwhile, Israel and the U.S. co-developed the Arrow weapon

system to defeat short and medium range threats. In East Asia, the Japanese and South Koreans also employ Patriot batteries. The Japanese now operate four Aegis BMD-capable ships and have co-developed the SM-3 Block IIA interceptor with the United States.[58]

These broad capabilities strengthen our collective ability for active defense and change the strategic calculus of force allocation for the U.S. In light of the significant growth of allied BMD capability, the U.S. should continue to press for increased allied burden sharing and re-assess deployment of its scarce, existing U.S. BMD means within each region to achieve its political ends. Each country also possesses offensive and passive means to aid in BMD. These resources, as well as similar U.S. means, must be part of any holistic BMD strategy.

An Incomplete Strategy

Fifth, current national strategy provides cursory consideration to the role of offensive and passive options to bolster regional BMD of the two U.S. power projection centers of gravity: forward airbases and naval forces. Negating this asymmetric attack thus requires the comprehensive use of all available passive, defensive, and offensive capabilities.[59] Long-range offensive counterair capabilities, such as CPGS, will be a key leg of this triad. Despite attack operations and active defense, both are limited in their capacity leaving forward strike capabilities vulnerable to attack. Thus, resiliency of the centers of gravity is another leg of the BMD triad. As the Pacific Air Forces (PACAF) has been actively working[60], the U.S. must assess and implement passive defense measures to operate through an attack. These measures include asset dispersion, redundancy, hardening, and rapid restoration. Relative to the costs of active BMD, these passive measures are extremely cost effective and must be part of a global strategy. This capability triad increases the protection of forward deployed forces and therefore must be considered together in any BMD strategy.

Process Innovation Required

Across the DoD, major weapon system acquisition is a complex laborious process defined by statutory and regulatory requirements, systems engineering, logistical planning, exhaustive testing, politics, and bureaucracy. Ballistic missile defense is no exception and arguably, even more extreme due to the technical complexities and scientific challenges it presents. Of the three primary weapon systems in the regional BMD architecture, each was delivered after an average of 21 years. .[61] [62] [63] The DoD must uncover ways of reducing mean capability delivery times, especially with the accelerated proliferation and new game-changing threats like hypersonic vehicles.

The Goldwater-Nichols Act (GNA) of 1986 and the National Defense Authorization Act (NDAA) of the same year have largely shaped the defense acquisition process of today. By centralizing acquisition authority at the Undersecretary of Defense for Acquisition, Technology, and Logistics (USD AT&L) and establishing an acquisition chain excluding the service chiefs, these seminal acts aimed to reduce program schedules, eliminate stove-piped acquisitions, and create clear oversight.[64] Still, one report contends it also fragmented the DoD acquisition system.[65] Weapon system deliveries averaging 21 years still today seems to confirm this finding. Across DoD, redundancy and duplication of effort between services still exists while the BMD portfolio's execution is best described as tribal in nature. Still, several potential opportunities exist to improve.

Duplicative Effort and its Implications

Whether in requirements generation or program execution, redundancy exists across DoD despite previous attempts to guide development of capabilities from a joint perspective. In 2003, the DoD implemented the Joint Capabilities Integration and Development System (JCIDS) to

mitigate the military service–dominated system for developing capabilities and meet the most essential warfighter needs.[66] In 2009, Congress mandated CCMD membership on the Joint Requirements Oversight Council (JROC). In theory, these reforms would quickly identify and rectify redundant capability development efforts by the services. While influential, any JROC decisions are merely advisory to service investment processes and reportedly are not always responsive to the combatant commander.[67] Ground robotics and remotely piloted aircraft (RPA) demonstrate how each service has independently developed nearly functionally equivalent systems due to reportedly unique requirements. As previously mentioned, the DoD has budgeted over $200 million for directed energy research in FY16. Yet, this funds $116 million, $67 million, and $30 million for existing independent Air Force, Navy, and Army research efforts, respectively.[68] These autonomous, parallel efforts not only sacrifice synergistic momentum to field capability sooner to all the services, but they will have exponential cost implications on future affordability. This $213 million is conservatively 10% of the total system lifecycle cost.[69] Thus, if all 3 efforts led to fielded systems, the remaining cost to the taxpayer would be another $1.8 billion for a single capability. Through a joint effort, it is not hard to project approximately $1 billion in cost avoidance. If the DoD is to achieve cost effectiveness, it must be more efficient by truly developing capabilities jointly from requirements generation through system disposal. Corporate BMD management would prove useful in this endeavor.

Tribal Management of the BMD Portfolio

Unity of command is a universal principle in military operations. Yet, central oversight of the BMD acquisition portfolio has only existed for the last eight years and no mechanism exists to holistically manage the department's BMD enterprise. At the enterprise level, the USD AT&L chairs the Missile Defense Executive Board (MDEB) providing oversight and guidance on

missile defense requirements.[70] Meanwhile, the Joint Integrated Air and Missile Defense Organization (JIAMDO) is chartered to independently implement the Chairman's Joint IAMD Vision 2020 through advocacy alone.[71] As the operational proponent for Global Ballistic Missile Defense, the U.S. Strategic Command (USSTRATCOM) synchronizes global BMD operations and manages the Warfighter Involvement Process (WIP) to create an list of BMD capability requirements from the myriad of stakeholders.[72] The military services operate and sustain the fielded weapon systems. Yet, no one organization has the authority or responsibility for the national BMD mission.

The BMD mission clearly meets the criteria for a DoD executive agent laid out in DoDI 5101.1. Nonetheless, an empowered principle agent for BMD does not exist to oversee and unify these competing stakeholder interests across the department. Even though all stakeholders help craft the MDA budget and the IPL, the MDA Director and the services retain the power to defer capability development to fund the higher priorities unintentionally diluting the users' requirements. Creating a DoD executive agent for BMD would enable DoD to efficiently manage this diverse portfolio and improve early acquisition efforts including joint requirements definition, efficient cross-service collaboration during S&T research, and consolidated program management of capabilities versus narrow service solutions.

Opportunities to Improve Acquisition Processes

Within the BMD enterprise, multiple opportunities exist to innovate the acquisition process and accelerate future capability deliveries. Both Congress and DoD have unwittingly provided potential advantages through different acquisition reform initiatives. The 2016 NDAA shifted overall responsibility for acquisition programs back to the service chiefs and provided streamlined options for rapid acquisition.[73] Meanwhile, DoD has continued to grant MDA

acquisition process flexibility[74], authorized new program accelerations models in the new DoD Instruction (DoDI) 5000.02, and implemented a long-range research and development program (LRRDP) focused on promising enabling technologies.[75]

Using its new rapid acquisition authorities, DoD can leverage the experience of previous rapid acquisitions, such as the Mine Resistant Armored Protection (MRAP) vehicles, to swiftly deliver capability to the field and codify an efficient rapid acquisition process to responsively support the field. Meanwhile, the DoD science and technology (S&T) community recently implemented a joint planning and coordination process, Reliance 21, to better manage its $12 billion annual budget[76]. This innovative framework should eliminate redundant S&T development activities by coordinating and aligning all services' efforts against capability gaps, developing collaborative responses, exploiting synergies, and potentially developing new opportunities.[77] In the aggregate, these initiatives should enable shorter cycle times for capability delivery, accelerate maturity of emerging technology, enhance future weapon systems, and deliver cost efficiencies.

Recommendations

Current U.S. strategy utilizes three metrics to score a cost-effective BMDS. Solutions must be affordable within current funding lines, provide better value when compared to other options, and cost less than the costs associated with a ballistic missile attack. The U.S. has arguably scored well in each category. Still, any future BMD acquisition strategy should include another equally important measure of cost effectiveness. Defensive solutions must achieve cost parity relative to the threats countered. In simpler terms, we must get off the wrong side of the cost curve where our national cost to defeat a threat is greater than an opponent's cost to employ the threat. For BMD to make this transition, the Commander of USSTRATCOM recently noted

that the U.S. must have a sound strategy to possess "an affordable, flexible, and achievable solution while allowing for innovation."[78] This strategy must be comprehensive, account for current realities, and anticipate future threats.

- **First recommendation:** perform a new Ballistic Missile Defense Review (BMDR) and update with each subsequent National Military Strategy. This should be coordinated with all BMD stakeholders to ensure efficient employment of all offensive, defensive, and passive capabilities while synchronizing BMD activities with current national security strategy.
- **Second recommendation:** designate a DoD Executive Agent for Global Missile Defense, possibly the Chairman of the Joint Chiefs of Staff. As BMD spans multiple services and domains, JIAMDO would be empowered and signal the need for greater coordination enabling improved portfolio management to minimize duplication or redundancy within the acquisition process.
- **Third Recommendation:** exploit recent acquisition reforms and MDA's DoD 5000 exemption to generate cost and schedule efficiencies. Within the deliberate DoD acquisition process, these authorities can provide additional execution flexibility.
- **Fourth Recommendation:** improve offensive and defensive counterair capabilities through emerging technology to augment existing BMD capability, counter advanced threats, and likely lower active defense engagement costs. These would include offensive strike weapons, active defensive measures, and passive measures to enhance interoperability and survivability.

- **Fifth recommendation:** increase international BMD contributions, especially their active kinetic means to increase global defended area and fairly share the cost burden. Continuing to grow allied capability is the most promising means to address the BMD supply versus demand challenge in the long term.

Collectively, the aforementioned recommendations will promote unity of effort across the BMD enterprise, reduce acquisition costs by combining efforts, significantly reduce cost per engagement, accelerate systems to the field, and move the U.S. to the right side of the cost curve.

Conclusion

Contrary to those who argue against ballistic missile defense spending, the United States has fielded a capable, yet limited, regional BMDS recognizing its necessity in an increasingly dangerous environment. Probability of war with another great power is at its highest point in decades due to aggressive regional acts by Russia, China, and other regional powers.[79] These countries continue to possess and improve their ballistic missile capabilities. Meanwhile, global trends drive a rapid rate of dynamic change defining the security environment[80] and downward pressure grows on U.S. defense spending. Within this context, the U.S. must solve the problem of maintaining a cost-effective ballistic missile deterrent and defense. Moving to the right side of the cost curve is critical. Ideally, all elements of national power must be brought to bear to deter use of ballistic missiles at the lowest cost. However, if non-kinetic efforts fail, a complete military strategy is crucial to deny the aggressor of his objectives.

Overall, the MDA and service are pursuing good solutions, but a lack of contemporary strategy and a unity of effort sub-optimize efforts to achieve a cost-effective regional BMD. Change has been constant and the six year-old U.S. BMD strategy is no longer current or adequate. The DoD must designate a BMD executive agent to synchronize military efforts and

perform a new strategic review in order to match ways and means to its military objective. This new plan must effectively employ current plans, leverage acquisition reform initiatives, continue the expansion of international partners' capabilities, and thoughtfully apply finite resources to augment existing systems with emerging technologies. The resulting effect has great potential to deliver a qualitative and quantitative capability overmatch in future conflict, whether limited war or total war. As the Chairman fittingly states, "Investments should follow a well-reasoned, cost-balanced course to develop and evolve IAMD capabilities that anticipate the threat while leveraging innovations in employment of kinetic and non-kinetic measures."[81] Through deliberate leadership, the U.S. can develop and execute a joint strategy leveraging finite resources to cost-effectively field a next-generation ballistic missile defense. The question remains whether DoD will develop and execute such a plan.

Notes

[1] While the author recognizes that homeland defense is a critical task, this paper focuses on the regional segment of the global missile defense mission. Thus, the consideration of missile defenses against strategic threats to the United States homeland (e.g. intercontinental ballistic missiles (ICBM)) lies outside the scope of this paper.

[2] Department of Defense, *Ballistic Missile Defense Review Report* (Washington, DC: Department of Defense, February 2010), i.

[3] Ian E. Rinehart, Steven A. Hildreth, and Susan V. Lawrence, "Ballistic Missile Defense in the Asia-Pacific Region: Cooperation and Opposition" (Congressional Research Service, April 3, 2015) 23-24.

[4] Department of Defense, *Ballistic Missile Defense Review Report, i*.

[5] Missile Defense Agency, "Missile Defense: The First Seventy Years" (Department of Defense, 8 August 2013), http://www.mda.mil/global/documents/pdf/first70.pdf, 1. With a nominal range of 200 miles and almost no guidance system, the V-2 was not decisively effective. Some believed the Germans possess the capability to strike targets in the United States with their new two-stage, 3,350-mile range A-9 or A-10 ballistic missiles if the war had lasted six more months. With another two years, German research could have produced the first intercontinental ballistic missile (ICBM) with a 15,000-mile range.

[6] Catherine McArdle Kelleher and Peter J. Dombrowski, eds., *Regional Missile Defense from a Global Perspective* (Stanford, California: Stanford University Press, 2015), 99.

[7] John R. Dabrowski, "Missile Defense: The First Seventy Years", 22.

[8] While the author recognizes that homeland defense is a critical task, this paper focuses on the regional segment of the global missile defense mission. Thus, the consideration of missile defenses against strategic threats to the United States homeland (e.g. intercontinental ballistic missiles (ICBM)) lies outside the scope of this paper.

[9] Per the 2015 National Military Strategy, "power projection is the key enabler to deter, deny, and defeat adversaries and strengthen our alliances and partnerships globally."

[10] Joint Chiefs of Staff, *The National Military Strategy of the United States of America 2015* (Department of Defense, June 2015), 15-17.

[11] Per William F. Bell, to qualify as an RMA, threat missile forces would have to apply technologies synergistically in innovative ways that give them a significant increase in their strategic, operational, and tactical war-fighting capabilities so that they effectively render our current ability to counter them cost-ineffective and thereby affect our conduct of global power projection.

[12] William F. Bell, "Have Adversary Missiles Become a Revolution in Military Affairs?," *Air & Space Power Journal*, no. September-October 2014 (n.d.): 47–70. Per Dorner and his co-authors, the A2/AD formula is straightforward and persistent throughout history: use all available means to gain control of an area while simultaneously denying the enemy the ability to do the same, primarily by preventing access and disrupting operations.

[13] National Air and Space Intelligence Center, "Ballistic and Cruise Missile Threat" (Department of Defense, 9 April 2009), 4.

[14] Missile Defense Agency, "The Threat," accessed 11 November 2015, http://www.mda.mil/system/threat.html.

[15] Pat McNelis and Phil Beaudoin, "Ballistic Missile Defense Senior Leader Overview, Joint BMD Training and Education Center (JBTEC)" (Space Operations Elective, Air War College, Maxwell Air Force Base, AL, 9 December 2015).

[16]National Air and Space Intelligence Center, "Ballistic and Cruise Missile Threat", 8-21. Russia has exported to countries including Egypt, Syria, India, Belarus, Kazakhstan, Libya, Turkmenistan, Ukraine, Vietnam, Yemen, Iran, and North Korea. China has exported ballistic missile technology to Pakistan, North Korea, and Iran. Meanwhile, North Korea had worked extensively with both Pakistan and Iran.

[17] Department of Defense, *Ballistic Missile Defense Review Report*, 7-8.

[18] Bell, "Have Adversary Missiles Become a Revolution in Military Affairs?", 53.

[19] Eleni Ekmektsioglou, "Hypersonic Weapons and Escalation Control in East Asia," *Strategic Studies Quarterly* 9, no. 2 (Summer 2015).

[20] Jeffrey Lin and P.W. Singer, "Offset This! China's Hypersonic Glider Flies for the Third Time This Year," *Popular Science*, 9 December 2014, http://www.popsci.com/offset-chinas-hypersonic-glider-flies-third-time-year.

[21] "Department of Defense Fiscal Year (FY) 2016 President's Budget Submission: Air Force Justification Book Volume 1 of 2, Aircraft Procurement, Air Force, Vol−1" (Department of Defense, February 2015), 1.

[22] Bell, "Have Adversary Missiles Become a Revolution in Military Affairs?", 55. The estimated cost of old-model SCUD missiles is from less than $1 million to $3 million, while the cost of the Chinese CSS-6 and CSS-7 was estimated at $500,000. Conservatively, $1M was used to estimate current cost of a CSS-6 or CSS-7.

[23] Ibid, 52.

[24] Department of Defense, *Ballistic Missile Defense Review Report*, 11-12.

[25] Ibid, 12.

[26] Kelleher and Dombrowski, *Regional Missile Defense from a Global Perspective*, 48.

[27] "Should U.S. Keep Spending $12.5B Each Year On Patriot Anti-Missile System?," *Breaking Defense*, 22 October 2012, http://breakingdefense.com/2012/10/should-u-s-keep-spending-12-5b-every-year-on-patriot-anti-miss/.

[28] Current THAAD program of record delivers 7 THAAD batteries. Four of these batteries have been activated, but only two are operational. The remaining two batteries are completing fielding and training requirements.

[29] Richard Scott, "Taking Aim: Maritime Ballistic Missile Defence in a UK Context" (Janes IHS, 5 February 2015), 3.

[30] Planned Initial Operational Capability (IOC) of the first Aegis Ashore is December 2015, as outlined in the EPAA.

[31] "Department of Defense Fiscal Year (FY) 2016 President's Budget Submission: Missile Defense Agency, Defense Wide Justification Book Volume 2b of 2, Procurement, Defense-Wide" (Department of Defense, February 2015), 1-13. NOTE: To date, THAAD Procurement is 186 interceptors with 100 more planned in the next 5 years. To date, Aegis SM-3 Procurement is 55 Block 1A & 148 Block IIA missiles with 312 more Block IIA in the next 5 years.

[32] Cristina Chaplain, *MISSILE DEFENSE: Actions Needed to Improve Transparency and Accountability*, GAO Report 11-372 (Washington, DC: United States Government Accountability Office, March 2011), 50.

[33] "Department of Defense Fiscal Year (FY) 2016 President's Budget Submission: Army Justification Book of Missile Procurement, Army," (Department of Defense, February 2015), 5.

[34] Admiral Cecil D. Haney, "Remarks" (2015 Space and Missile Defense Symposium, Huntsville, Alabama, 11 August 2015), https://www.stratcom.mil/speeches/2015/140/2015_Space_and_Missile_Defense_Symposium/.

[35] Department of Defense, "DoD Topline: 2001-2020," *Defense.gov*, accessed 20 November 2015, http://www.defense.gov/Portals/1/features/2015/0215_budget/info01.jpg.

[36] "Historical Funding for MDA FY85-15" (Missile Defense Agency), accessed 6 November 2015, http://www.mda.mil/global/documents/pdf/histfunds.pdf.

[37] One additional AN/TPY-2 forward-based surveillance radar was procured in 2012 and two of these radars were fielded in Southern Europe and Japan in 2011 and 2014, respectively. A key component of the European Phased Adaptive Approach (EPAA), the first Aegis Ashore weapon system, is on schedule to become operational in the next month but is not easily relocated as the BMDR planned. Additionally, the Missile Defense Agency (MDA) implemented unplanned cost efficiencies to procure a seventh Terminal High Altitude Area Defense (THAAD) battery not previously resourced by DoD. While successfully fielded, both the AN/TPY-2 and the THAAD fire control element are out of production limiting future agility to build additional combat power.

[38] "Raytheon Awarded $559 Million for SM-3 Block IB," accessed 11 November 2015, http://www.prnewswire.com/news-releases/raytheon-awarded-559-million-for-sm-3-block-ib-300076763.html.

[39] "US Scraps Final Phase of European Missile Shield," *BBC News*, 16 March 2013, http://www.bbc.com/news/world-us-canada-21812161.

[40] Amy Butler, "PTSS Kill Leaves Hole In Missile Defense Sensor Plan," 29 April 2013, http://aviationweek.com/awin/ptss-kill-leaves-hole-missile-defense-sensor-plan.

[41] Bell, "Have Adversary Missiles Become a Revolution in Military Affairs?", 48.

[42] Charles Timothy "Chuck" Hagel, "The Defense Innovation Initiative" (Department of Defense, 15 November 2014), http://www.defense.gov/Portals/1/Documents/pubs/OSD013411-14.pdf.

[43] John Keller, "Northrop Grumman to Improve Air Battle Management Capabilities of Army's IBCS Network," 1 May 2015, http://www.militaryaerospace.com/articles/2015/05/air-battle-management.html.

[44] Daniel Wasserbly, "US Army Eyes Electromagnetic Railgun as Navy Test Plans Unfold," *Jane's Defence Weekly*, 28 July 2015. The U.S. Navy estimates the cost of a Hyper Velocity Projectile (HVP) at approximately $25 thousand versus $8-12 million for a kinetic interceptor.

[45] Jason D. Ellis, "Directed-Energy Weapons: Promise and Prospects" (Washington, DC: Center for a New American Security, April 2015), http://www.cnas.org/sites/default/files/publications- pdf/CNAS_Directed_Energy_Weapons_April-2015.pdf, 4.

[46] House Armed Services Committee, "National Defense Authorization Act For Fiscal Year 2016, Report of the Committee on Armed Services House of Representatives" (Washington, DC: US House of Representatives, n.d.), http://www.dtic.mil/congressional_budget/pdfs/FY2016_pdfs/House_Report_114-102.pdf.

[47] James M. Acton, "Silver Bullet: Asking the Right Questions About Conventional Prompt Global Strike" (Carnegie Endowment of International Peace, 2013), 4.

[48] Eleni Ekmektsioglou, "Hypersonic Weapons and Escalation Control in East Asia", 43.

[49] "Advanced Hypersonic Weapon (AHW)," *Army Technology*, accessed 3 November 2015, http://www.army-technology.com/projects/advanced-hypersonic-weapon-ahw/.

[50] Eleni Ekmektsioglou, "Hypersonic Weapons and Escalation Control in East Asia", 48.

[51] Sydney J. Freedberg Jr., "Laser on A Truck: Army's Role in Offset Strategy," *Breaking Defense*, 10 December 2014, http://breakingdefense.com/2014/12/laser-on-a-truck-the-armys-role-in-the-offset-strategy/.

[52] Department of Defense, *Ballistic Missile Defense Review Report*, vi.

[53] Ibid, iv.

[54] Doug Richardson, "NATO's First Theatre Ballistic Missile Defence Capability Becomes Operational," *Jane's Missiles & Rockets*, 1 February 2011.

[55] Joseph W. Kirschbaum, *REGIONAL MISSILE DEFENSE: DOD's 2014 Report Generally Addressed Required Reporting Elements, but Excluded Additional Key Details*, GAO Report 15-32 (Washington, DC: United States Government Accountability Office, December 2014), 21.

[56] Agence France-Presse, "Germany Opts For MEADS Missile Defense System," *Defense News*, 11 June 2015, http://www.defensenews.com/story/defense/2015/06/09/germany-opts-for-meads-missile-defense-system/28741425/.

[57] Jeremy Binnie, "GCC Commits to Regional Ballistic Missile Defence," *Jane's Defence Weekly*, 15 May 2015.

[58] Joseph W. Kirschbaum, *REGIONAL MISSILE DEFENSE: DOD's 2014 Report Generally Addressed Required Reporting Elements, but Excluded Additional Key Details*, 21.

[59] Joint Chiefs of Staff, "Joint Integrated Air and Missile Defense: Vision 2020" (Department of Defense, 5 December 2013), 1.

[60] Kenneth R. Dorner, Major William B. Hartman, and Teague, Major Jason M., "Back to the Future: Integrated Air and Missile Defense in the Pacific," *Air & Space Power Journal* 29, no. 1 (February 2015): 61.

[61] United States Army, "The Patriot Air Defense System," accessed 15 November 2015, http://www.history.army.mil/books/www/wwwapena.htm. According to the Army, Patriot was delivered the fastest at 20 years in 1985.

[62] "Aegis Ballistic Missile Defense (Aegis BMD)," accessed 5 November 2015, http://www.globalsecurity.org/military/systems/ship/systems/aegis-bmd.htm. Per Global Security, Aegis BMD was delivered after 21 years when emergency activated in 2004.

[63] Missile Defense Agency, "Terminal High Altitude Area Defense (THAAD)," accessed 5 November 2015, http://www.mda.mil/system/thaad.html. MDA states that THAAD was delivered after 22 years in 2012.

[64] M. Thomas Davis, "Put Service Chiefs Back in the Acquisition Business," *SIGNAL Magazine*, 25 November 2015, http://www.afcea.org/content/?q=Blog-put-service-chiefs-back-acquisition-business.

[65] Michael J. Sullivan, *DEFENSE ACQUISITIONS: Observations on Whether the Military Service Chiefs' Role in Managing and Overseeing Major Weapon Programs Should Be Expanded*, GAO Report 14-520 (Washington, DC: United States Government Accountability Office, May 2014), 7. GAO contends these efforts contributed to the fragmentation between

three key acquisition decision-support processes of requirements determination, resource allocation, and the acquisition management system.

[66] John H. Pendleton, *Defense Management: COCOM Perspectives on Joint Requirements*, GAO Report 11-527R (Washington, DC: United States Government Accountability Office, 20 May 2011), 1.

[67] Ibid, 5.

[68] House Armed Services Committee, "National Defense Authorization Act For Fiscal Year 2016, Report of the Committee on Armed Services House of Representatives."

[69] Cost Assessment and Program Evaluation Office, "Operating and Support Cost-Estimating Guide" (Office of the Secretary of Defense, March 2014), 2-2.

[70] MDEB membership includes representatives from across DoD, the military services, and the National Security Staff. Per the Secretary of Defense, MDA is exempt from the standard DoD acquisition and requirements generation process.

[71] Geoffrey F. Weiss, "Seeing 2020: America's New Vision for Integrated Air and Missile Defense," *Joint Forces Quarterly* JFQ 76, no. 1st Quarter 2015, 107.

[72] Department of Defense, *Ballistic Missile Defense Review Report*, 42.

[73] Aaron Mehta and Joe Gould, "McCain Wins Big With Acquisition Reform," *Defense News*, 5 October 2015, http://www.defensenews.com/story/defense/policy-budget/2015/10/05/mccain-wins-big-acquisition-reform/73217188/.

[74] The SECDEF has exempted the MDA from standard DoD acquisition requirements.

[75] Frank Kendall, "Long Range Research and Development Plan (LRRDP) Direction and Tasking" (Department of Defense, 29 October 2014).

[76] Michele Mackin, *DOD RAPID INNOVATION PROGRAM: Some Technologies Have Transitioned to Military Users, but Steps Can Be Taken to Improve Program Metrics and Outcomes*, GAO Report 15-421 (Washington, DC: United States Government Accountability Office, May 2015), 3.

[77] "Reliance 21 Operating Principles: Bringing Together the DoD Science and Technology Enterprise" (Department of Defense, January 2014), 1.

[78] Haney, "Remarks."

[79] Joint Chiefs of Staff, *The National Military Strategy of the United States of America 2015*, 4.

[80] *Quadrennial Defense Review 2014* (Washington, DC: Department of Defense, 4 March 2014), 3-8.

[81] Joint Chiefs of Staff, "Joint Integrated Air and Missile Defense: Vision 2020", 5.

Bibliography

Acton, James M. “Silver Bullet: Asking the Right Questions About Conventional Prompt Global Strike.” Carnegie Endowment of International Peace, 2013.

“Advanced Hypersonic Weapon (AHW).” *Army Technology*. Accessed 3 November 2015. http://www.army-technology.com/projects/advanced-hypersonic-weapon-ahw/.

“Aegis Ballistic Missile Defense (Aegis BMD).” Accessed 5 November 2015. http://www.globalsecurity.org/military/systems/ship/systems/aegis-bmd.htm.

Agence France-Presse. “Germany Opts For MEADS Missile Defense System.” *Defense News*, 11 June 2015. http://www.defensenews.com/story/defense/2015/06/09/germany-opts-for-meads-missile-defense-system/28741425/.

Ahmed, Mutahir. "Missile Defense and South Asia: A Pakistani Perspective." *The Impact of US Ballistic Missile Defenses on Southern Asia* (2002).

Air-Sea Battle Office. “Air Sea Battle: Service Collaboration to Address Anti-Access & Area Denial Challenges.” Department of Defense, May 2013.

Auger, Martin. *Defence Procurement Organizations: A Global Comparison*. 2015.

Ballard, Maj William H., USAF Col Mark C. Harysch, Byron S. Hall, and Kenneth R. Dorner. "Operationalizing Air-Sea Battle in the Pacific." *Air and Space Power Journal* (2015).

“Ballistic Missile Defence.” *North Atlantic Treaty Organization*. Accessed 9 November 2015. http://www.nato.int/cps/en/natohq/topics_49635.htm.

Barno, Lieutenant General David W., Nora Bensahel, Matthew Irvine, and Travis Sharp. " Sustainable Pre-eminence: Reforming the U.S. Military at a Time of Strategic Change." Washington, DC: Center for New American Security, May 2012. http://www.cnas.org/files/documents/publications/CNAS_SustainablePreeminence_BarnoBensahelIrvineSharp_0.pdf

Berteau, David, Joachim Hofbauer, and Stephanie Sanok Kostro. *Implementation of the Weapon Systems Acquisition Reform Act of 2009: A progress report*. Washington, DC: Center for Strategic and International Studies, 2010.

Bell, William F. “Have Adversary Missiles Become a Revolution in Military Affairs?” *Air & Space Power Journal*, no. September-October 2014 (n.d.): 47–70.

Binnie, Jeremy. “GCC Commits to Regional Ballistic Missile Defence.” *Jane’s Defence Weekly*, 15 May 2015.

Butler, Amy. “PTSS Kill Leaves Hole In Missile Defense Sensor Plan,” 29 April 2013. http://aviationweek.com/awin/ptss-kill-leaves-hole-missile-defense-sensor-plan.

Cost Assessment and Program Evaluation Office. “Operating and Support Cost-Estimating Guide.” Office of the Secretary of Defense, March 2014.

Chaplain, Cristina. *MISSILE DEFENSE: Actions Needed to Improve Transparency and Accountability*. GAO Report 11-372. Washington, DC: United States Government Accountability Office, March 2011.

Dabrowski, John R.. “Missile Defense: The First Seventy Years.” Missile Defense Agency, 8 August 2013.

Davis, M. Thomas. “Put Service Chiefs Back in the Acquisition Business.” *SIGNAL Magazine*, 25 November 2015. http://www.afcea.org/content/?q=Blog-put-service-chiefs-back-acquisition-business.

Defense Business Board. "Linking and Streamlining the Defense Requirements, Acquisitions, and Budget Processes." Report to the Secretary of Defense. April 2012. http://dbb. defense. gov/pdf/FY12-02_Linking_and_Streamlining_the_Def_Req_Acq_and_Budget_ Processes.pdf.

Department of Defense. *Ballistic Missile Defense Review Report*. Washington, DC: Department of Defense, 2010.

Department of Defense Directive 5101.1. *DoD Executive Agent*, 21 November 2003.

Department of Defense Directive 5134.09. *Missile Defense Agency*, 17 September 2009.

“Department of Defense Fiscal Year (FY) 2016 President’s Budget Submission: Army Justification Book of Research, Development, Test & Evaluation, Army RDT&E − Volume I, Budget Activity 2.” Department of Defense, February 2015, 68-72.

“DoD Topline: 2001-2020.” *Defense.gov*. Accessed November 20, 2015. http://www.defense.gov/Portals/1/features/2015/0215_budget/info01.jpg.

“Department of Defense Fiscal Year (FY) 2016 President’s Budget Submission: Air Force Justification Book Volume 1 of 2, Aircraft Procurement, Air Force, Volume 1.” Department of Defense, February 2015.

“Department of Defense Fiscal Year (FY) 2016 President’s Budget Submission: Army Justification Book of Missile Procurement, Army,.” Department of Defense, February 2015.

“Department of Defense Fiscal Year (FY) 2016 President’s Budget Submission: Missile Defense Agency, Defense Wide Justification Book Volume 2b of 2, Procurement, Defense-Wide.” Department of Defense, February 2015.

Department of Defense Instruction 5000.02. *Operation of the Defense Acquisition System*, 7 January 2015.

“DoD Research and Engineering Enterprise: Strategic Guidance.” Assistant Secretary of Defense, Research and Engineering, 1 May 2014.

Dorner, Kenneth R., Major William B. Hartman, and Teague, Major Jason M. “Back to the Future: Integrated Air and Missile Defense in the Pacific.” *Air & Space Power Journal* 29, no. 1 (February 2015): 61.

Eckstein, Megan. “Navy Pursuing Upgraded Railgun, Higher-Power Laser Gun By 2020.” *USNI News*, 28 July 2015. http://news.usni.org/2015/07/28/navy-pursuing-upgraded-railgun-higher-power-laser-gun-by-2020.

Ekman, Kenneth P. "Applying Cost Imposition Strategies against China." *Strategic Studies Quarterly* 9, no. 1 (2015).

Ekmektsioglou, Eleni. “Hypersonic Weapons and Escalation Control in East Asia.” *Strategic Studies Quarterly* 9, no. 2 (Summer 2015).

Ellis, Jason D.. “Directed-Energy Weapons: Promise and Prospects.” Washington, DC: Center for a New American Security, April 2015. http://www.cnas.org/sites/default/files/publications-pdf/CNAS_Directed_Energy_Weapons_April-2015.pdf.

Freedberg Jr., Sydney J. “Army Missile Defense Must Step Up Its Game: Heidi Shyu.” *Breaking Defense*. 8 October 2015. http://breakingdefense.com/2015/08/army-missile-defense-must-step-up-its-game-heidi-shyu/.

Freedberg Jr., Sydney J. “Laser on A Truck: Army’s Role in Offset Strategy.” *Breaking Defense*, 10 December 2014. http://breakingdefense.com/2014/12/laser-on-a-truck-the-armys-role-in-the-offset-strategy/.

Guzansky, Yoel, and Yiftah S. Shapir. "Iran Goes Ballistic." *Middle East Quarterly* (2015).

Hagel, Charles Timothy “Chuck”. “The Defense Innovation Initiative.” Department of Defense, 15 November 2014. http://www.defense.gov/Portals/1/Documents/pubs/OSD013411-14.pdf.

Haney, Admiral Cecil D. “Remarks.” Address. 2015 Space and Missile Defense Symposium, Huntsville, Alabama, 11 August 2015, https://www.stratcom.mil/speeches/2015/140/2015_Space_and_Missile_Defense_Symposium/.

Harper, Jon. “Navy Working on ‘Sci-Fi’ Weapons.” *National Defense*, November 2015.

Heim, Jacob L. "The Iranian Missile Threat to Air Bases." *Air and Space Power Journal* 29, no. 4 (2015): 27-50.

“High Energy Laser Mobile Demonstrator.” US Army Space and Missile Defense Command, n.d. http://www.smdc.army.mil/factsheets/helmd.pdf.

“Historical Funding for MDA FY85-15.” Missile Defense Agency. Accessed 6 November 2015. http://www.mda.mil/global/documents/pdf/histfunds.pdf.

House Armed Services Committee. “National Defense Authorization Act For Fiscal Year 2016, Report of the Committee on Armed Services House of Representatives.” Washington, DC: US House of Representatives, n.d. http://www.dtic.mil/congressional_budget/pdfs/FY2016_pdfs/House_Report_114-102.pdf.

Hoyler, Marshall. "China’s ‘antiaccess’ ballistic missiles and US active defense." *Naval War College Review* 63, no. 4 (2010): 84-105.

John, Miriam, and Robert Stein. *Report of the Defense Science Board 2008 Summer Study on Capability Surprise. Volume 2: Supporting Papers*, Defense Science Board, Washington DC, 2010.

Joint Chiefs of Staff. “Joint Integrated Air and Missile Defense: Vision 2020.” Department of Defense, 5 December 2013.

Joint Chiefs of Staff. *The National Military Strategy of the United States of America 2015*. Department of Defense, June 2015.

Joint Publication 3-01, Countering Air and Missile Threats. Washington, DC: Department of Defense, 2012.

Kelleher, Catherine McArdle, and Peter J. Dombrowski, eds. *Regional Missile Defense from a Global Perspective*. Stanford, California: Stanford University Press, 2015.

Keller, John. "Northrop Grumman to Improve Air Battle Management Capabilities of Army's IBCS Network," 1 May 2015. http://www.militaryaerospace.com/articles/2015/05/air-battle-management.html.

Kendall, Frank. "Long Range Research and Development Plan (LRRDP) Direction and Tasking." Department of Defense, 29 October 2014.

Kirschbaum, Joseph W.. *REGIONAL MISSILE DEFENSE: DOD's 2014 Report Generally Addressed Required Reporting Elements, but Excluded Additional Key Details*. GAO Report 15-32. Washington, DC: United States Government Accountability Office, December 2014.

Krepinevich Jr, Andrew F. "Strategy in a Time of Austerity." *Foreign Affairs* 91, no. 6 (2012): 58.

LaGrone, Sam. "Pentagon Drops Air Sea Battle Name, Concept Lives On." *USNI News*, 20 January 2015. http://news.usni.org/2015/01/20/pentagon-drops-air-sea-battle-name-concept-lives.

Lin, Jeffrey, and P.W. Singer. "Offset This! China's Hypersonic Glider Flies for the Third Time This Year." *Popular Science*. 9 December 2014. http://www.popsci.com/offset-chinas-hypersonic-glider-flies-third-time-year.

Lyngaas, Sean. "Kendall Welcomes House Acquisition Reform Bill, with Caveats," 13 April 2015. https://fcw.com/articles/2015/04/13/kendall-on-house-acquisition-bill.aspx.

Mackin, Michele. *DOD RAPID INNOVATION PROGRAM: Some Technologies Have Transitioned to Military Users, but Steps Can Be Taken to Improve Program Metrics and Outcomes*. GAO Report 15-421. Washington, DC: United States Government Accountability Office, May 2015.

Magnuson, Stew. "Air Force Research Lab Tries to Stay Ahead of Rivals." *National Defense*, November 2015.

McInnis, Kathleen J. "The 2015 National Military Strategy: Background and Questions for Congress." Congressional Research Service, 29 July 2015. http://www.fas.org/sgp/crs/natsec/IN10333.pdf.

McNelis, Pat, and Phil Beaudoin. "Ballistic Missile Defense Senior Leader Overview, Joint BMD Training and Education Center (JBTEC)." Lecture. Space Operations Elective, Air War College, Maxwell Air Force Base, AL, 9 December 2015.

McNicol, David. *Are Changes in Acquisition Policy and Process and in Funding Climate Associated With Cost Growth?*. Institute for Defense Analyses, Alexandria VA, 2015.

Mehta, Aaron, and Joe Gould. "McCain Wins Big With Acquisition Reform." *Defense News*, 5 October 2015. http://www.defensenews.com/story/defense/policy-budget/2015/10/05/mccain-wins-big-acquisition-reform/73217188/.

Mills, Colonel James C. "Long Range Precision Fires Milestone A Shaping Brief." Program Executive Office Missiles and Space, 17 September 2015.

National Air and Space Intelligence Center. "Ballistic and Cruise Missile Threat." Department of Defense, 9 April 2009.

Obama, Barack. *National Security Strategy*. Washington, DC: United States Government, February 2015.

Pendleton, John H.. *Defense Management: COCOM Perspectives on Joint Requirements*. GAO Report 11-527R. Washington, DC: United States Government Accountability Office, 20 May 2011.

Performance of the Defense Acquisition System, 2015 Annual Report. Washington, DC: Under Secretary of Defense, Acquisition, Technology, and Logistics (USD[AT&L]), 16 September 2015.

Pinkston, Daniel. *The North Korean Ballistic Missile Program*. Maroon Ebooks, 2015.

Podvig, Pavel. "Russia Tests Hypersonic Glide Vehicle." *Jane's Intelligence Review*, 4 June 2015.

"Preservation Hall: MDAA Hosts Congressional Roundtable on the Impact of Budget Uncertainty on Missile Defense Programs." Missile Defense Advocacy Association, 6 November 2015. http://missiledefenseadvocacy.org/alert/preservation-hall-mdaa-hosts-congressional-roundtable-on-the-impact-of-budget-uncertainty-on-missile-defense-programs/.

Quadrennial Defense Review 2014. Washington, DC: Department of Defense, 4 March 2014.

"Raytheon Awarded $559 Million for SM-3 Block IB." Accessed 23 November 2015. http://www.prnewswire.com/news-releases/raytheon-awarded-559-million-for-sm-3-block-ib-300076763.html.

"Reliance 21 Operating Principles: Bringing Together the DoD Science and Technology Enterprise." Department of Defense, January 2014.

Richardson, Doug. "NATO's First Theatre Ballistic Missile Defence Capability Becomes Operational." *Jane's Missiles & Rockets*, 1 February 2011.

Rinehart, Ian E., Steven A. Hildreth, and Susan V. Lawrence. "Ballistic Missile Defense in the Asia-Pacific Region: Cooperation and Opposition." Congressional Research Service, 3 April 2015.

Scott, Richard. "Taking Aim: Maritime Ballistic Missile Defence in a UK Context." Janes IHS, 5 February 2015.

Secretary of the Air Force Public Affairs. "James Named New Principal DOD Space Advisor." *U.S. Air Force*, 7 October 2015. http://www.af.mil/News/ArticleDisplay/tabid/223/Article/622265/james-named-new-principal-dod-space-advisor.aspx.

Shaffer, Alan. “Communities of Interest: Collaborating on Technology Challenges.” *Defense Acquisition, Technology, and Logistics*, March 2015.

“Should U.S. Keep Spending $12.5B Each Year On Patriot Anti-Missile System?” *Breaking Defense*. 22 October 2012. http://breakingdefense.com/2012/10/should-u-s-keep-spending-12-5b-every-year-on-patriot-anti-miss/.

Sugden, Bruce M. "Speed Kills: Analyzing the Deployment of Conventional Ballistic Missiles." *International Security* 34, no. 1 (2009): 113-146.

Sullivan, Michael J. *DEFENSE ACQUISITIONS: DOD’s Requirements Determination Process Has Not Been Effective in Prioritizing Joint Capabilities*. GAO Report 08-1060. Washington, DC: United States Government Accountability Office, September 2008.

Sullivan, Michael J. *DEFENSE ACQUISITIONS: Observations on Whether the Military Service Chiefs’ Role in Managing and Overseeing Major Weapon Programs Should Be Expanded*. GAO Report 14-520. Washington, DC: United States Government Accountability Office, May 2014.

Sullivan, Michael J. *DEFENSE ACQUISITIONS: Rapid Acquisition of MRAP Vehicles*. GAO Report 10-155T. Washington, DC: United States Government Accountability Office, 8 October 2009.

Sullivan, Michael J. *DOD WEAPON SYSTEMS: Missed Trade-off Opportunities During Requirements Reviews*. GAO Report 11-502. Washington, DC: United States Government Accountability Office, June 2011.

“Terminal High Altitude Area Defense (THAAD).” Accessed 5 November 2015. http://www.mda.mil/system/thaad.html.

“The Threat.” Accessed 11 November 2015. http://www.mda.mil/system/threat.html.

United States Army. “The Patriot Air Defense System.” Accessed 15 November 2015. http://www.history.army.mil/books/www/wwwapena.htm.

“US Scraps Final Phase of European Missile Shield.” *BBC News*, 16 March 2013. http://www.bbc.com/news/world-us-canada-21812161.

Versprille, Allyson. “Analysts: China’s Missile Program the Greatest Long-Term Threat to U.S. Security.” *National Defense Magazine*, 20 August 2015. http://www.nationaldefensemagazine.org/blog/Lists/Posts/Post.aspx?ID=1925.

Wasserbly, Daniel. “US Army Eyes Electromagnetic Railgun as Navy Test Plans Unfold.” *Jane’s Defence Weekly*, 28 July 2015.

Weiss, Geoffrey F. “Seeing 2020: America’s New Vision for Integrated Air and Missile Defense.” *Joint Forces Quarterly* JFQ 76, no. 1st Quarter 2015 (n.d.).

Williams, Edie, and Alan R. Shaffer. “The Defense Innovation Initiative: The Importance of Capability Prototyping.” *Joint Forces Quarterly*, 2nd Quarter 2015.

Williams, Shara, Jeffrey A. Drezner, Megan McKernan, Douglas Shontz, and Jerry M. Sollinger. *Rapid Acquisition of Army Command and Control Systems*. Santa Monica CA: RAND Arroyo Center, 2014.

Work, Bob. “The Third U.S. Offset Strategy and Its Implications for Partners and A.” U.S. Department of Defense, 28 January 2015. http://www.defense.gov/News/Speeches/Speech-View/Article/606641/the-third-us-offset-strategy-and-its-implications-for-partners-and-allies.